B.3 16 JANUARY 1973

Under the influence of the eastward-moving 500 mb upper trough shown on Figures B-9 and B-11 (see also Figure B-10, 16/00Z surface analysis), cyclogenesis occurred in and near the area to the east of the northern end of the Persian Gulf (an area generally favorable for cyclogenesis). This area was under the region of strong, positive-vorticity advection to the east of the upper trough axis (marked R for rising vertical motion on Figures B-9 and B-11). Two surface lows formed between 15/12Z and 16/00Z, one over the lower

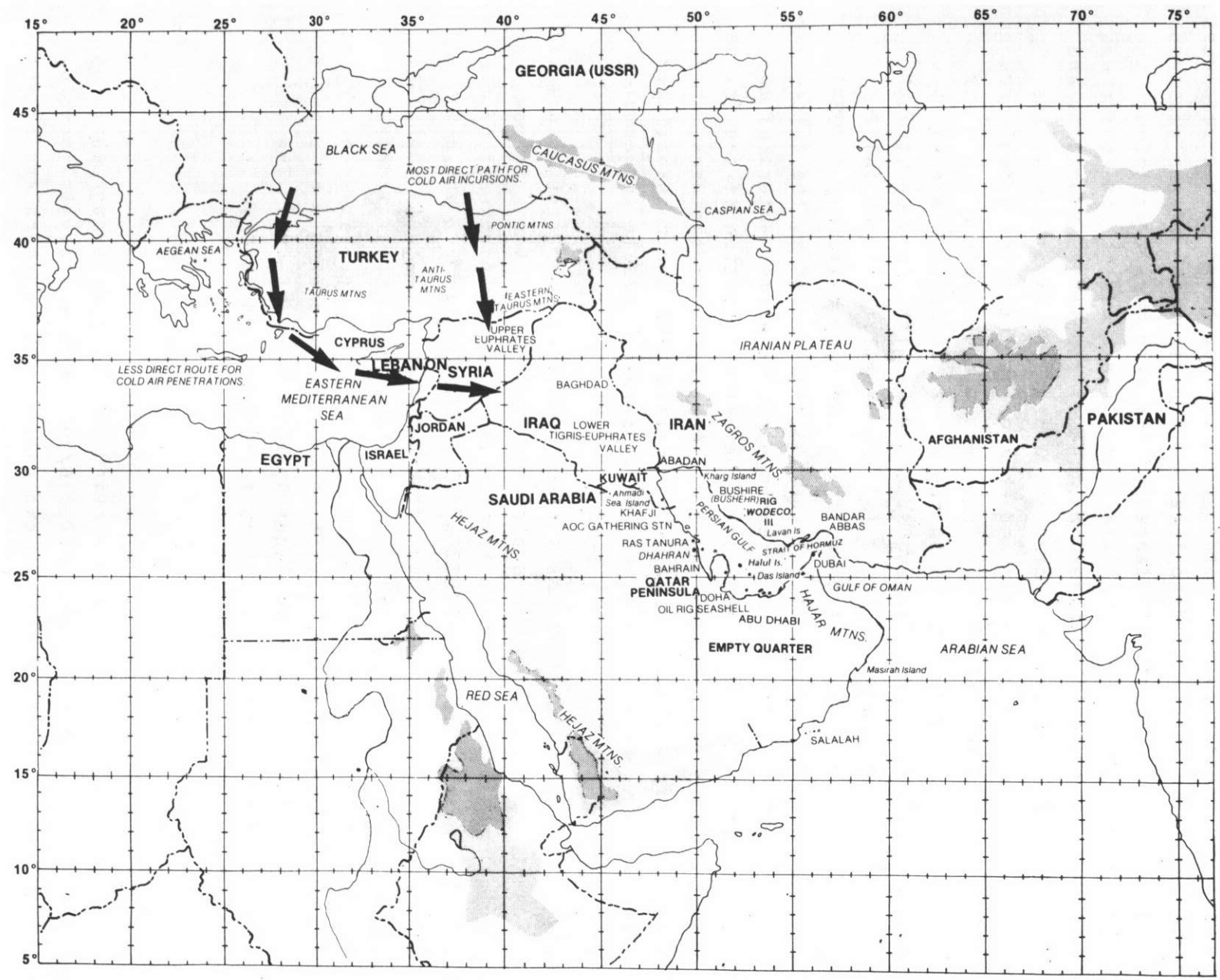

Figure B-2. Paths of cold air incursions into upper Euphrates valley prior to onset of shamal.

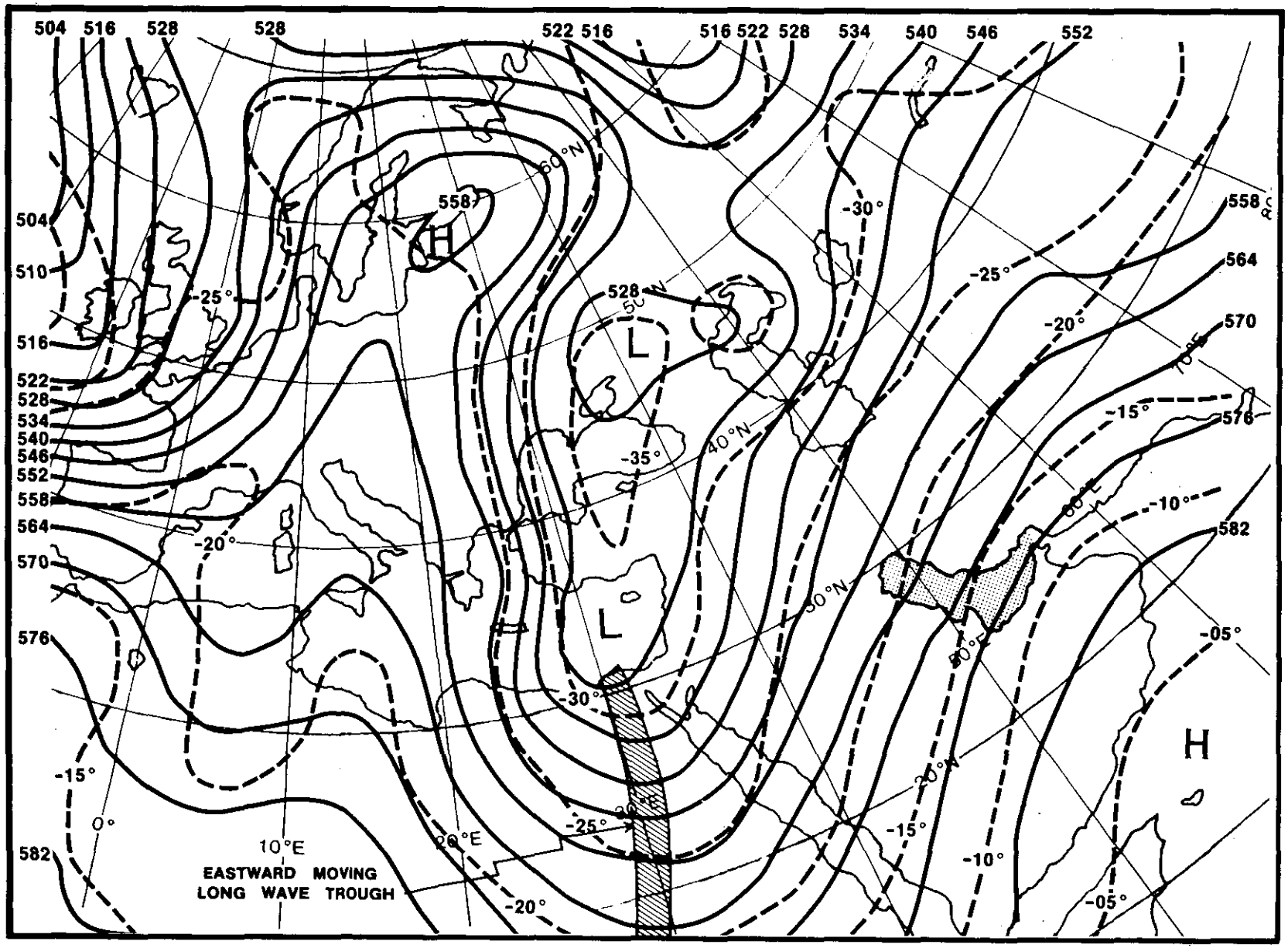

Figure B-3. 500 mb analysis, 15 Jan 1973 0000Z.

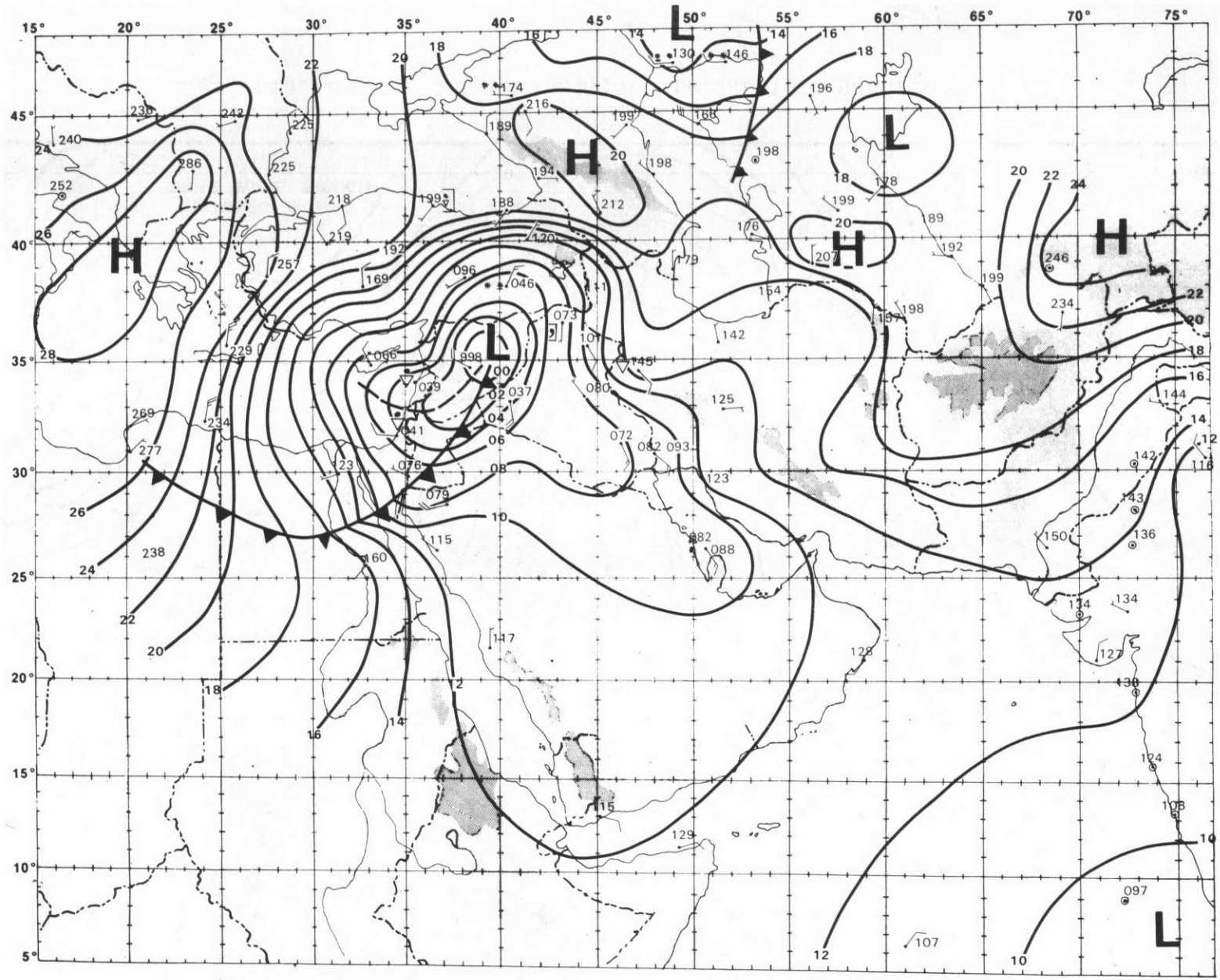

Figure B-4. Surface analysis, 15 Jan 1973 0000Z.

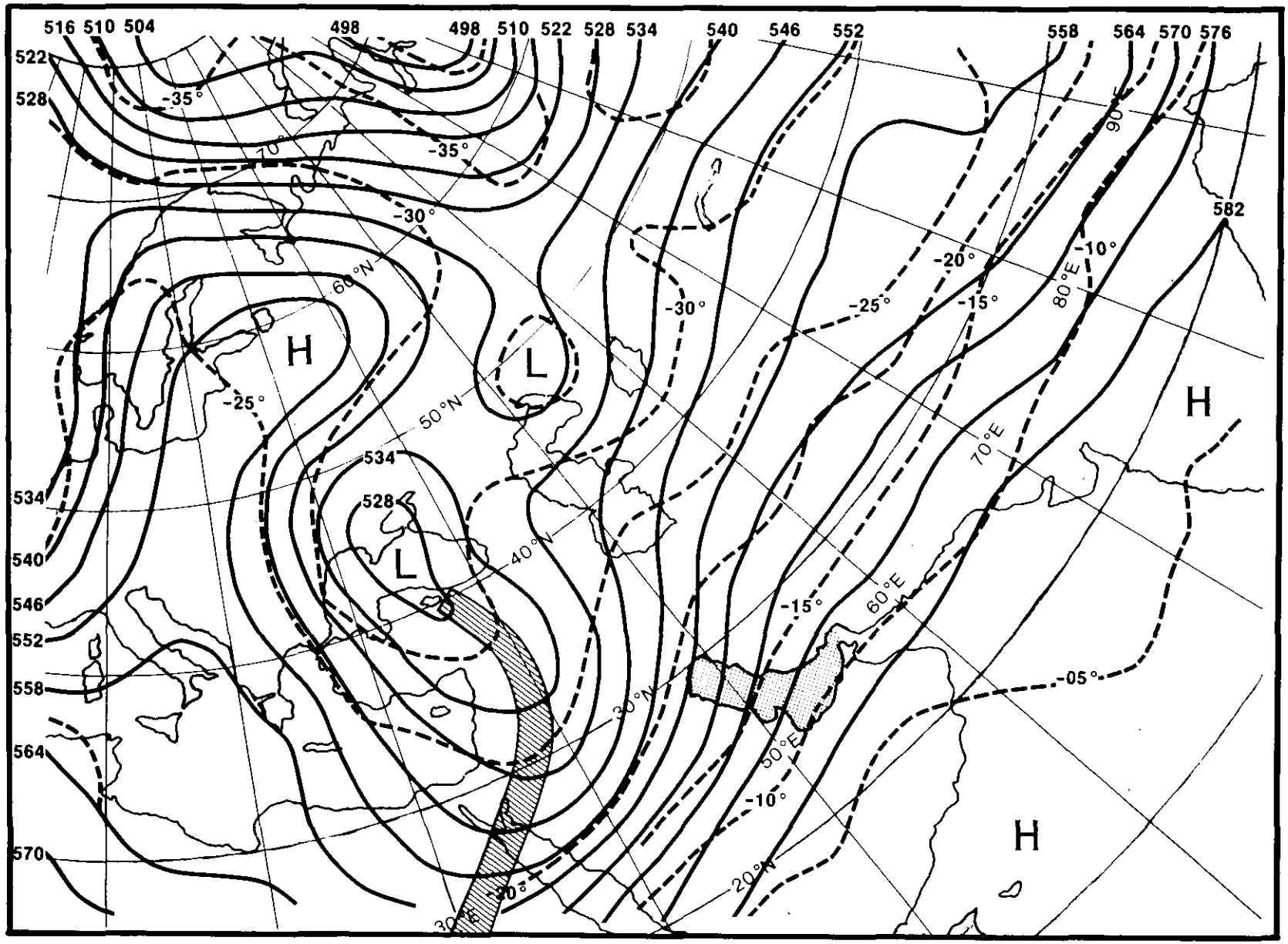

Figure B-5. 500 mb analysis, 15 Jan 1973 1200Z.

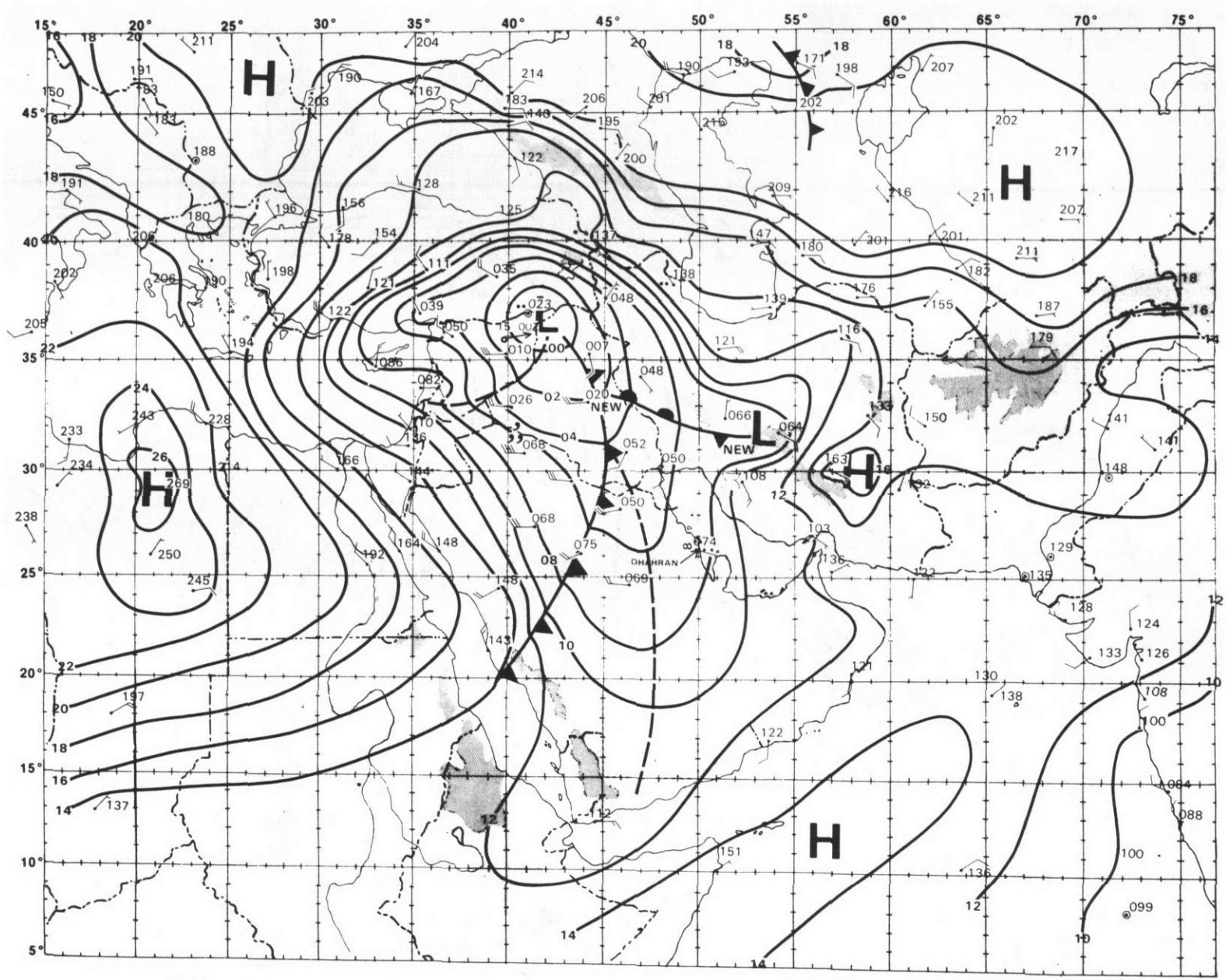

Figure B-6a. Surface analysis, 15 Jan 1973 1200Z.

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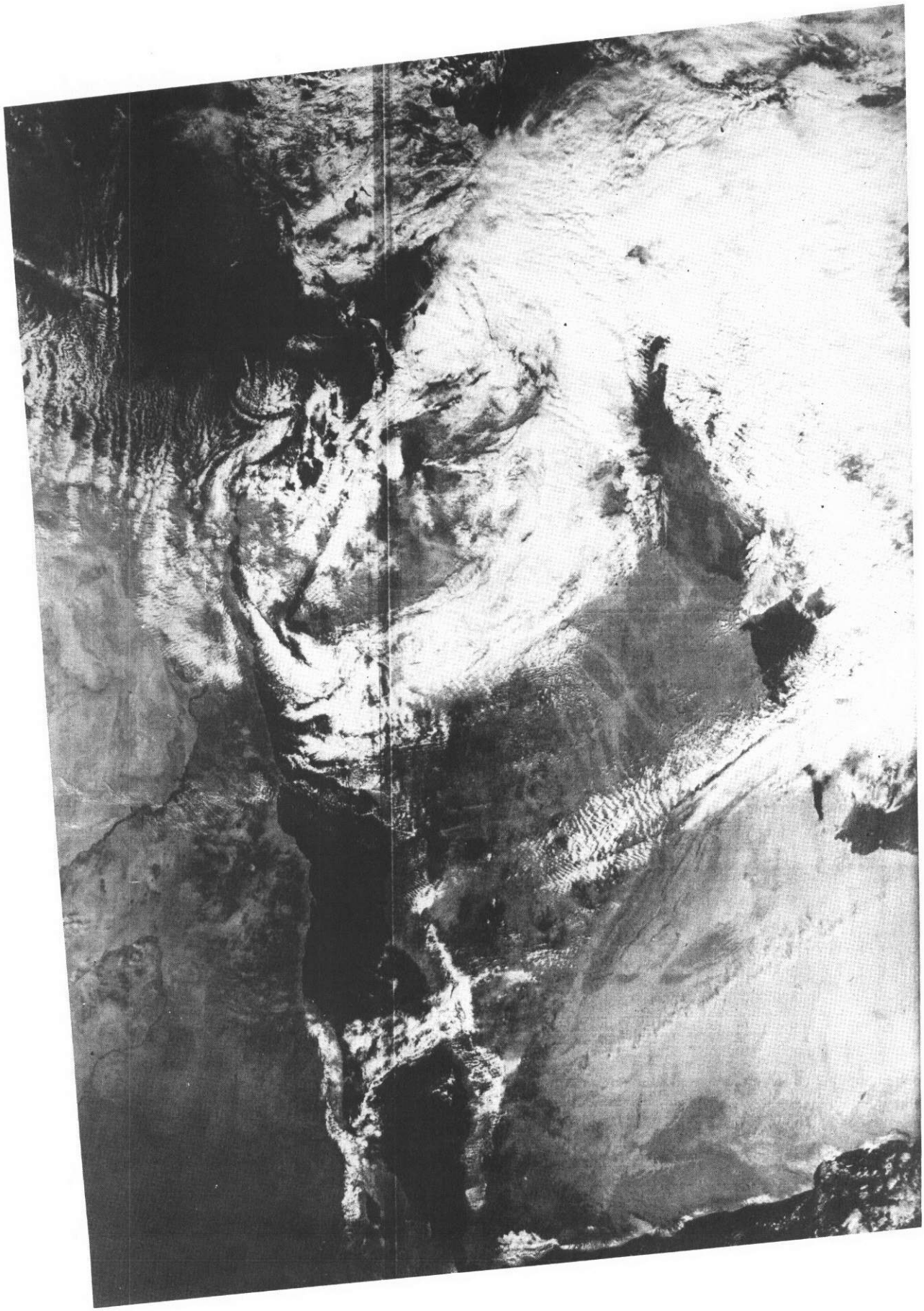

Figure B-6b, left. DMSP visible image, 15 Jan 1973 local noon.

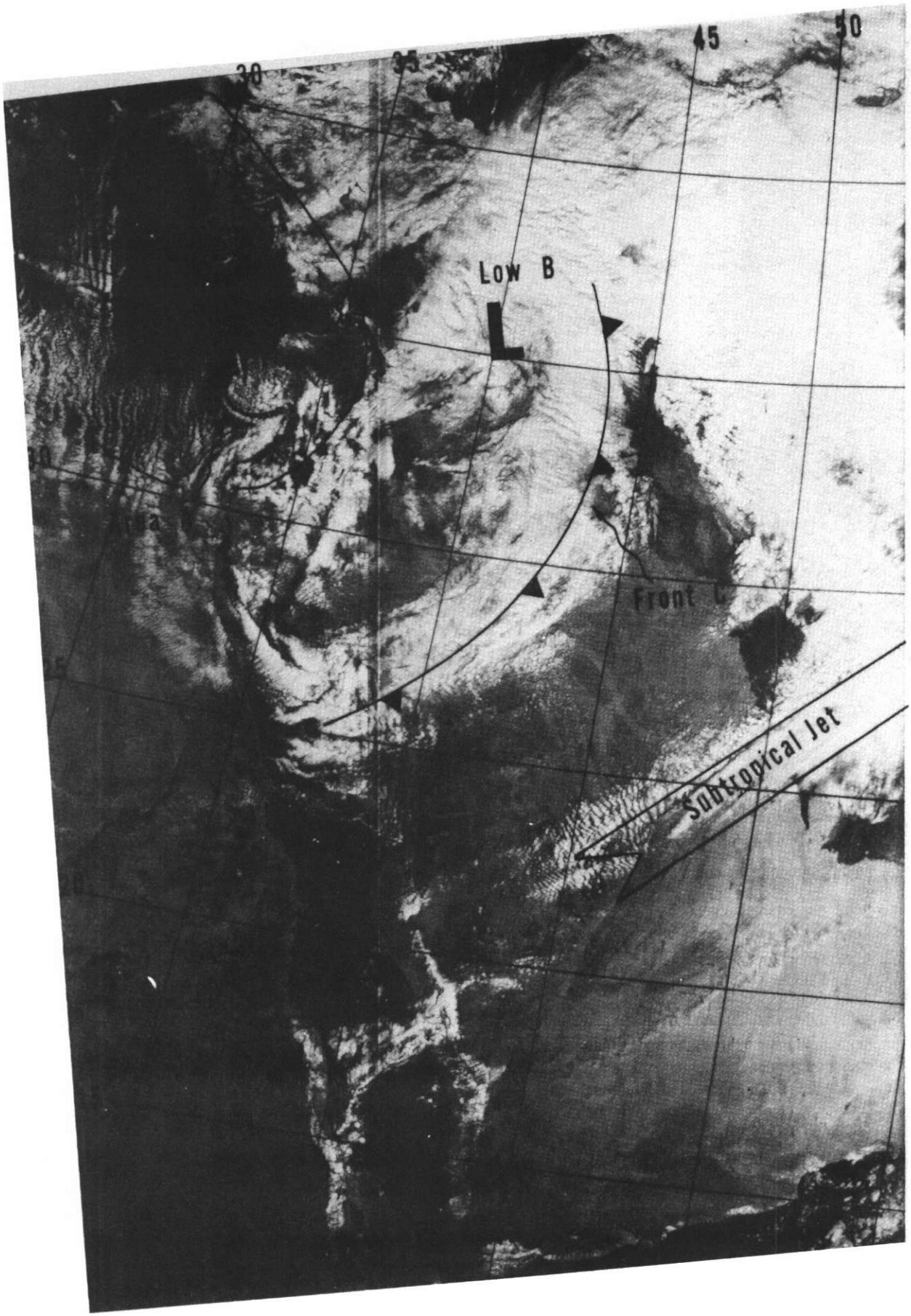

Figure B-6b, left. Continued.

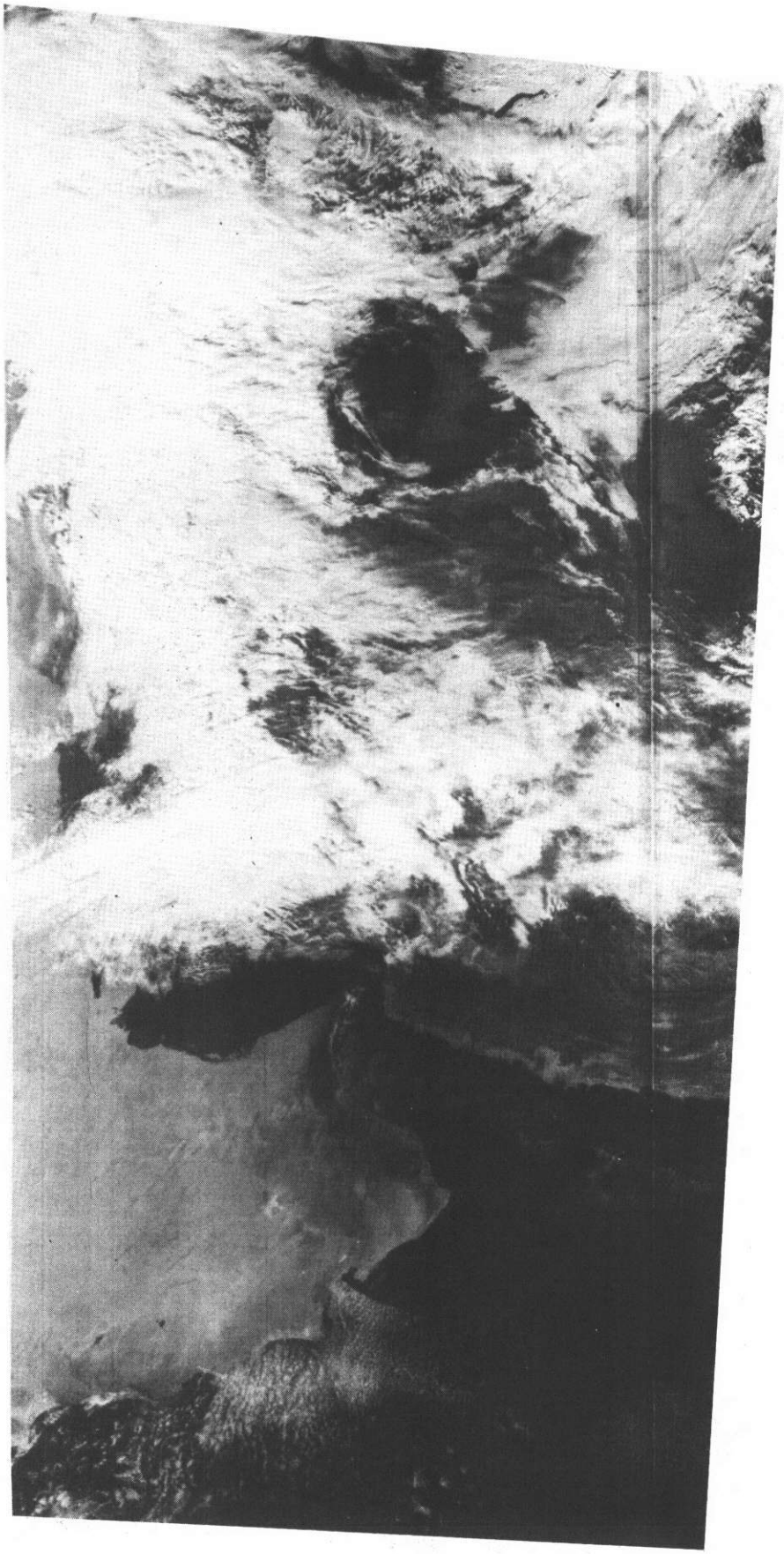

Figure B-6b, right. Continued.

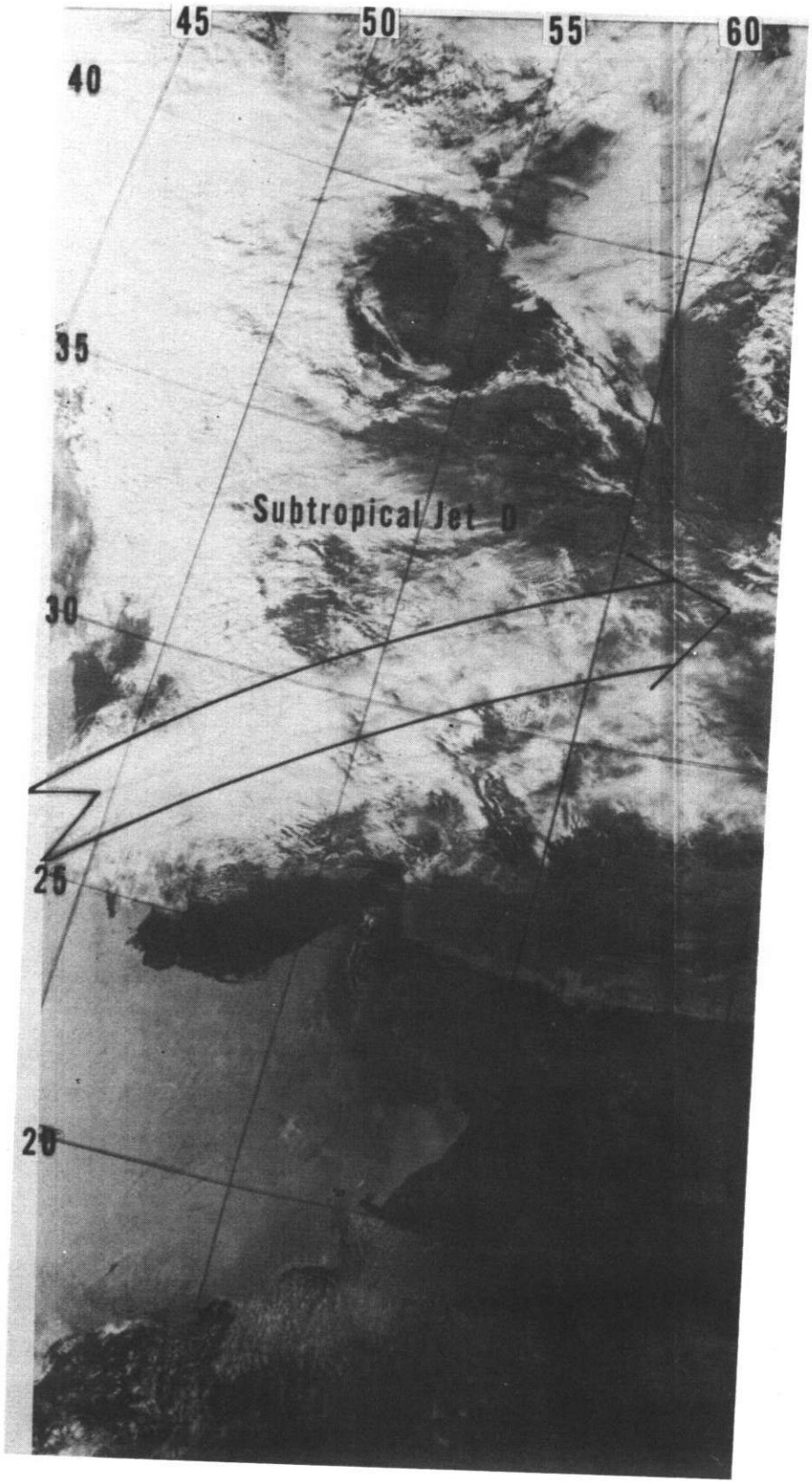

Figure B-6b, right. Continued.

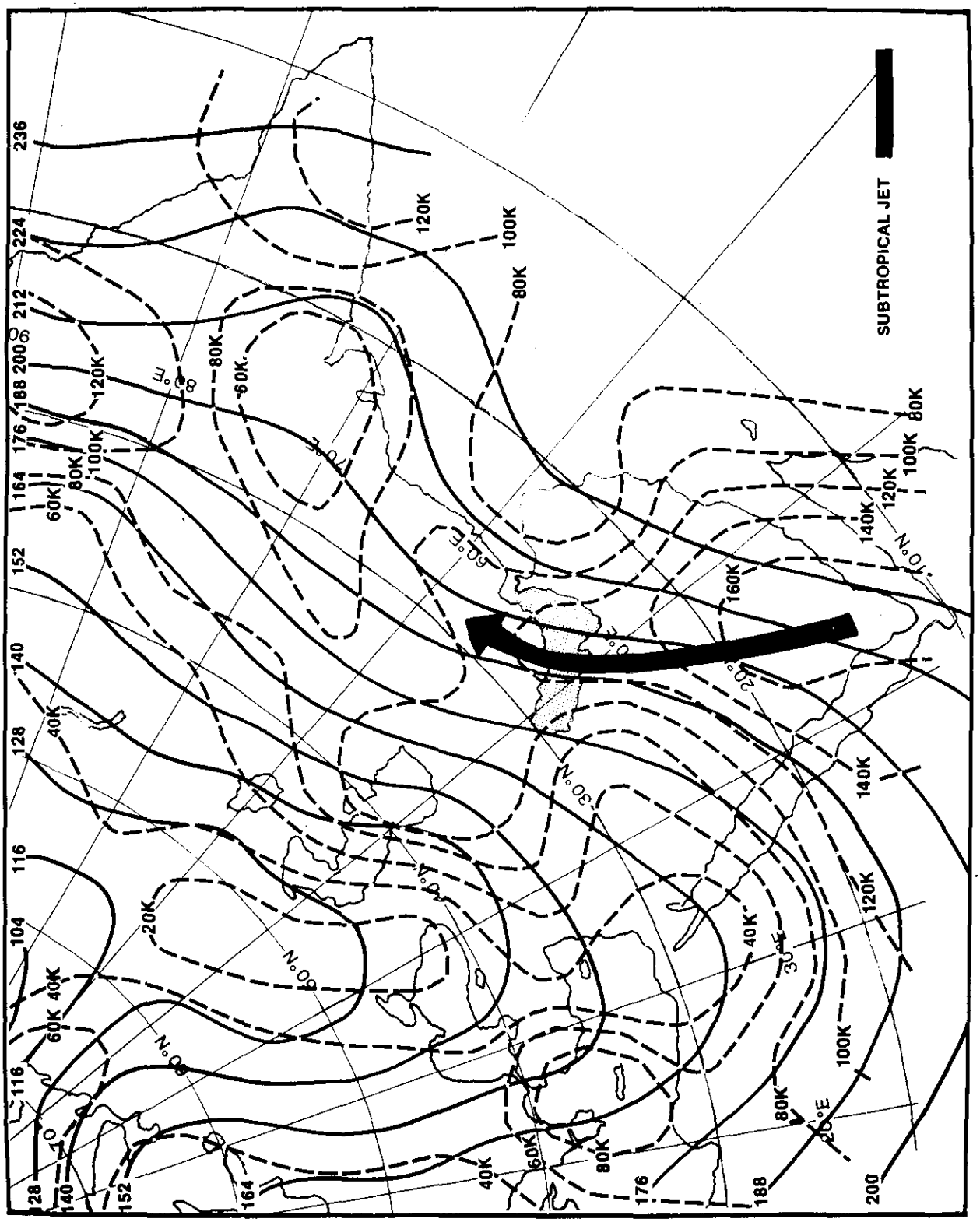

Figure B-7. 200 mb analysis, 15 Jan 1973 0000Z.

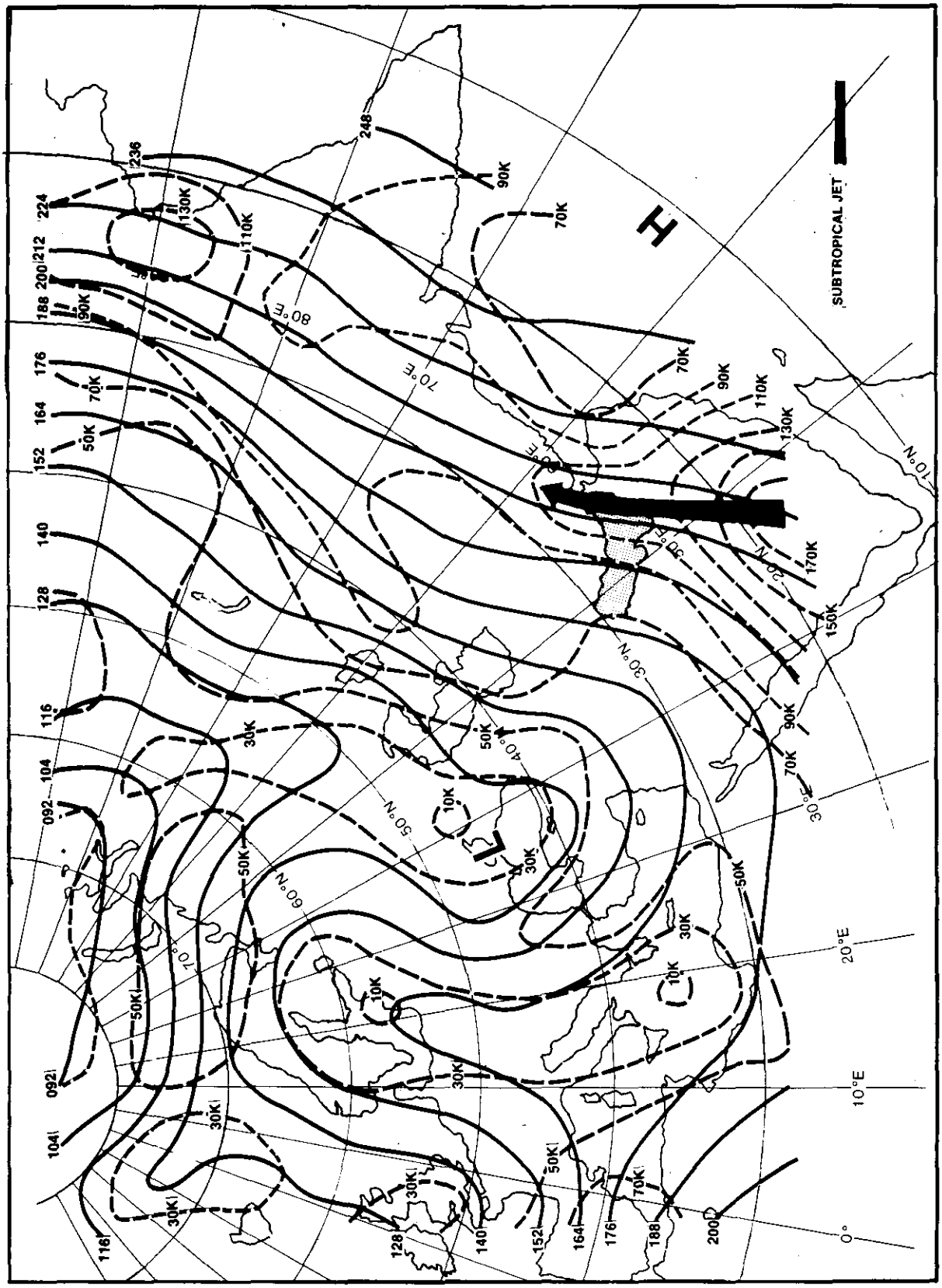

Figure B-8. 200 mb analysis, 15 Jan 1973 1200Z.

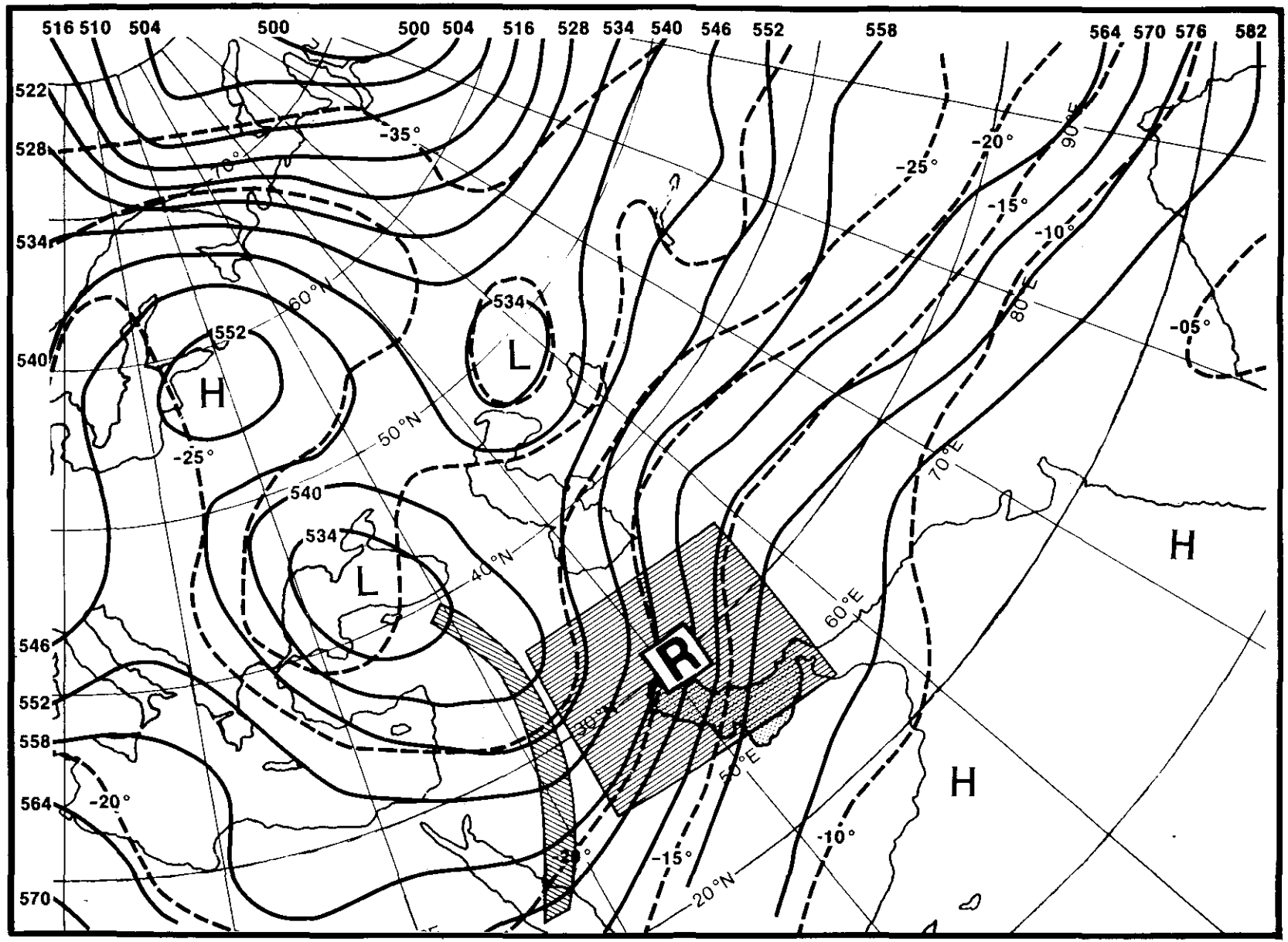

Figure B-9. 500 mb analysis, 16 Jan 1973 0000Z.

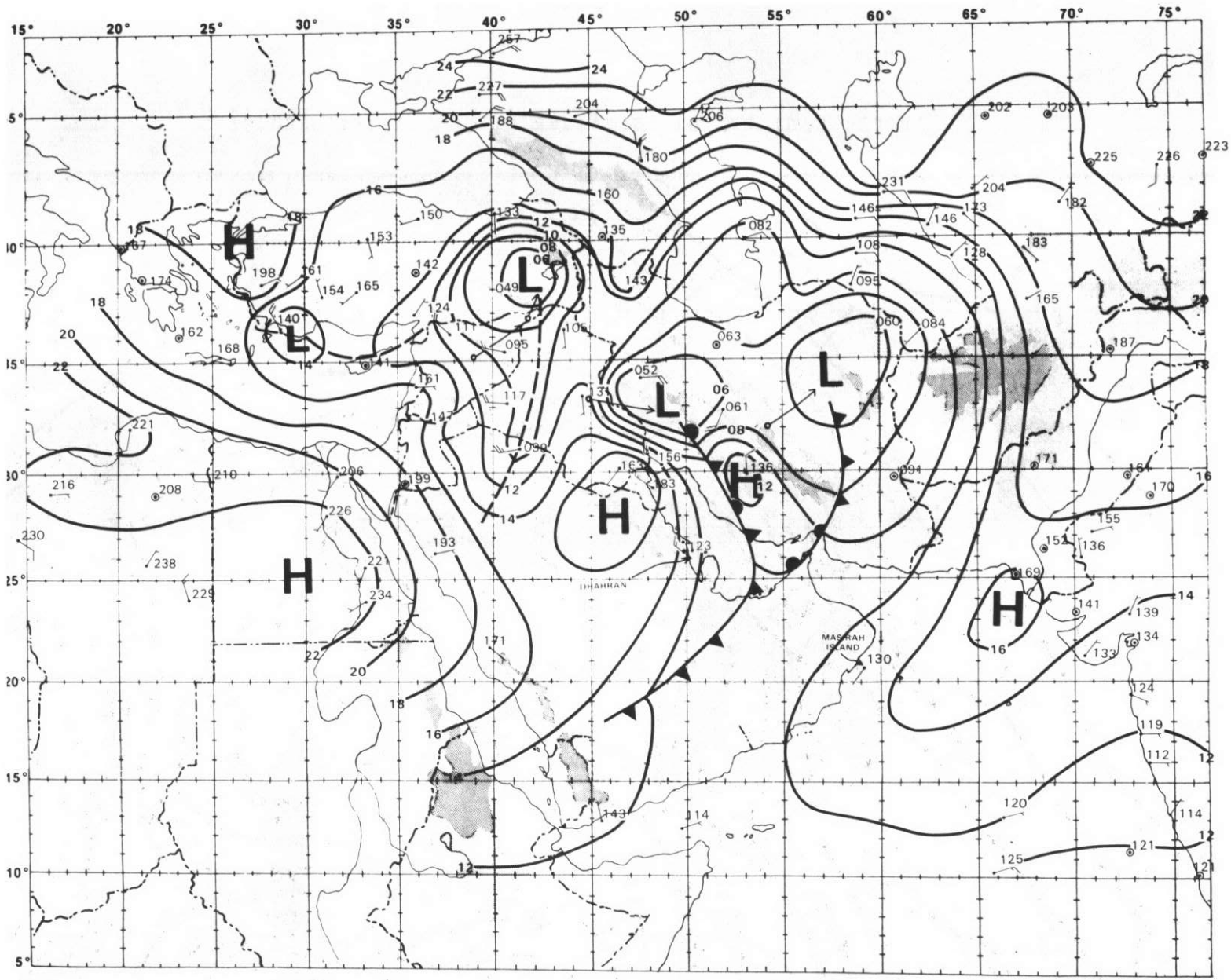

Figure B-10. Surface analysis, 16 Jan 1973 0000Z.

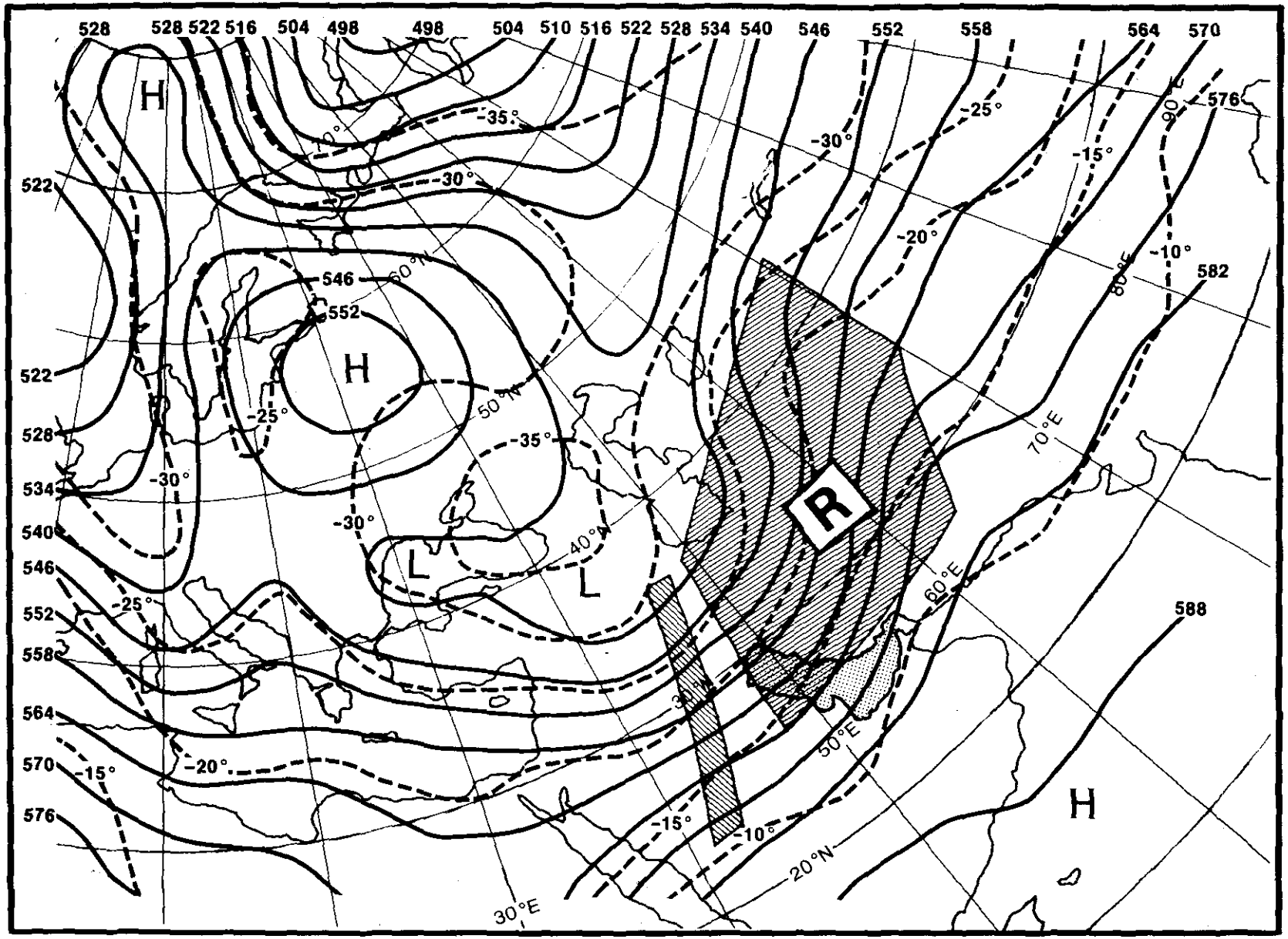

Figure B-11. 500 mb analysis, 16 Jan 1973 1200Z.

Tigris-Euphrates valley near 33°N, 45°E, and the other over central Iran near 32°N, 54°E. They appear on the 16/00Z surface analysis, Figure B-10, as 1005 mb lows over western and eastern Iran.

These surface lows then tracked further northeastward under the northeasterly airstream at 500 mb to new positions at 16/12Z near 33°N, 55°E, and 37°N. 63°E, respectively (Figure B-12). The parent surface low, which was located near 35°N, 39°E at 15/00Z, moved to the northeast to near 38°N, 42°E (see 16/00Z surface analysis, Figure B-10), where it remained quasi-stationary and subsequently weakened, under the 500 mb low center position (see 16/12Z 500 mb analysis, Figure B-11).

Without detailed surface data (such as that available in Appendix A), it is difficult to fix the time of the frontal intrusion into the Gulf that marked the onset of the shamal in this case study. Wind reports available from the west coast of the central Gulf indicate that the onset had not yet occurred at 15/12Z (the wind at Dhahran, near 26°N, 50°E was east-southeasterly, as shown in Figure B-6a). The shamal may have just begun at 16/00Z -- at Dhahran the wind shifted northwesterly to 15 kt, as shown in Figure B-10 -- and seems to have become established by 16/12Z when the wind at Bahrain, near Dhahran, was northwesterly at 20 kt with blowing sand.

It is also difficult to do more than speculate about the strength of the winds over the open waters of the Persian Gulf. Wind speeds over these waters are frequently higher than at shore stations. It is not unreasonable, therefore, to expect that wind speeds in the zone near the cold front are at or near gale force.

The DMSP visible satellite image for noon local time on 16 Jan, Figure B-13, shows cloudiness labeled area E near the Strait of Hormuz in the vicinity of 26.5°N, 56.5°E, and a band of cloudiness labeled band F along and near the southeastern coast of the Arabian Peninsula. It is difficult to locate the cold front which forms the leading edge of the shamal, but the analyses shown in Figures B-10 and B-12 seem a reasonable fit to the available data.

The cold front advanced rapidly southeastward down the Gulf over the Arabian Peninsula early on 16 Jan, but apparently slowed its forward movement later in the day. Area E could have been the result of a small area of warm air overrunning the frontal surface near the triple point in the vicinity of the Strait of Hormuz. Band F is too indistinct to be definitely related to a cold front. A portion of band F could be the result of local sea breeze effects along the coast of the Arabian Sea.

Typical cold frontal cloudiness cannot be detected in this instance, although an air mass contrast may exist near the coastal area. The cloud pattern in and near Band F indicates an onshore component to the wind west of 55°E, so the front probably had not yet reached the shoreline. Further

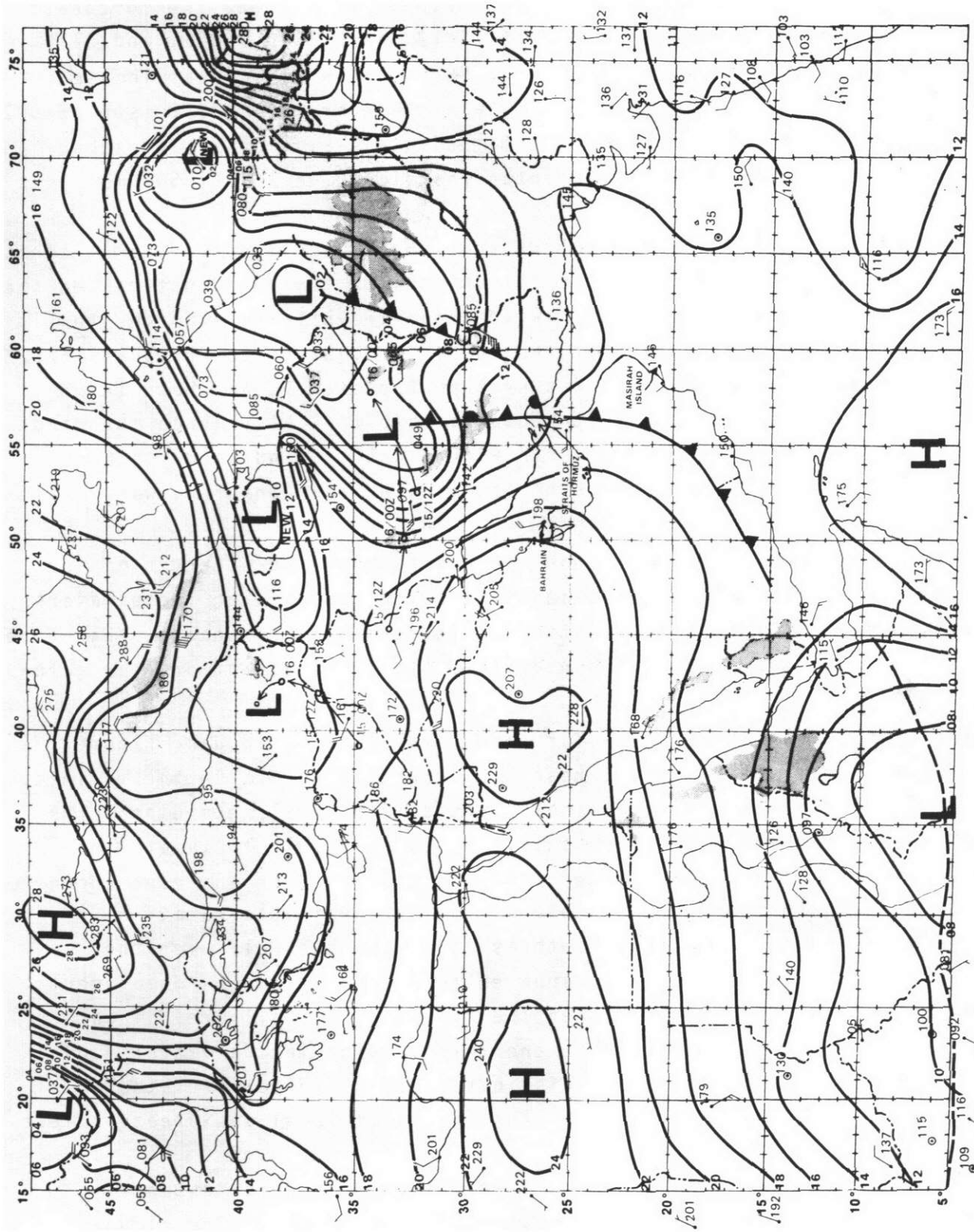

Figure B-12. Surface analysis, 16 Jan 1973 1200Z.

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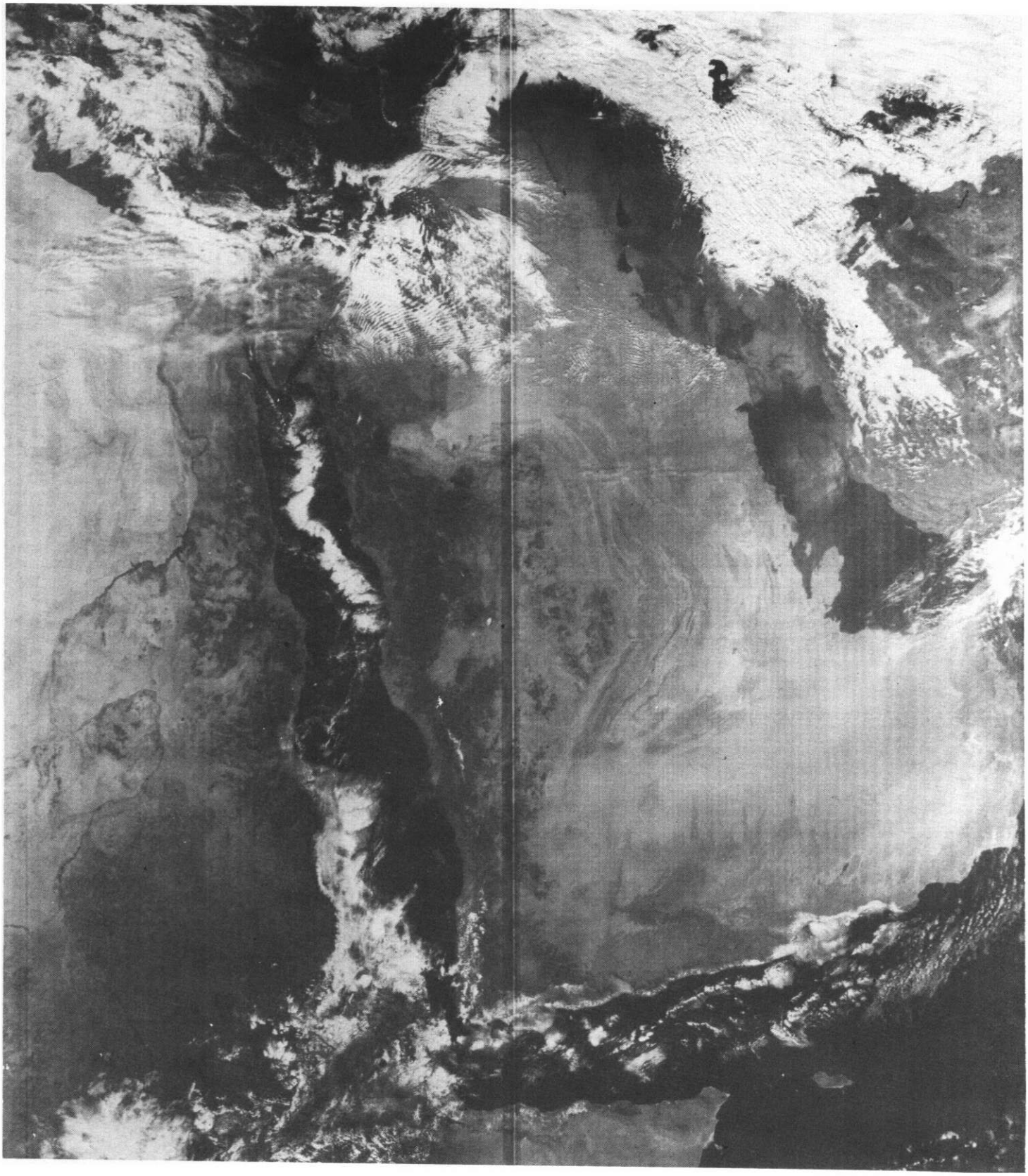

Figure B-13. DMSP visible image, 16 Jan 1973 local noon.

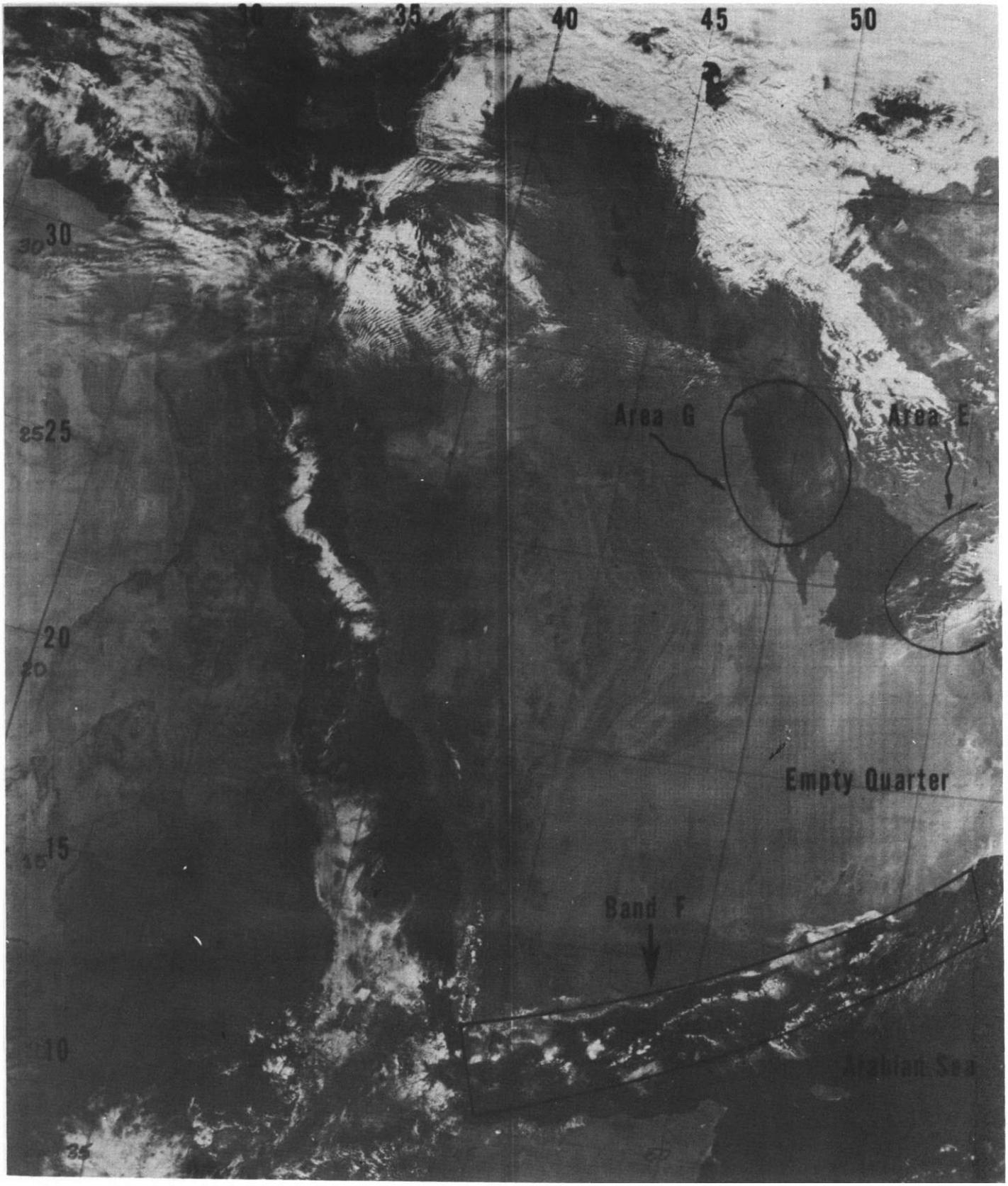

Figure B-13. Continued.

confirmation lies in the fact that following a cold frontal passage, the winds at Masirah Island (near 20.5°N, 59°E) typically blow northwesterly 20-25 kt with blowing dust and sand. These conditions, however, did not occur on 16 Jan.

It should be noted that the cold air behind the cold front is subject to rapid modification by warming from below as it advances southeastward over the Arabian Peninsula, much of which is desert. This includes the so-called "Empty Quarter" in the southeastern part of the Peninsula, which is one of the world's most arid regions. The amount of solar insolation incident upon the Peninsula in mid-winter is considerably less than during the mid-summer maximum. Nonetheless, during mid-winter the solar insolation may be enough to warm the earth's surface to the point that it can significantly modify some of the cool air masses which pass over the empty quarter behind the fronts associated with the shamal.

Except in the immediate region of the Persian Gulf, there is little low level moisture available over the Arabian Peninsula to produce frontal cloudiness. By the time these fronts reach the Arabian Sea coastline, they often have lost much of their cold frontal characteristics because of modification of the cold air mass as it passes over the warmer land mass and lack of low level moisture. The "front" therefore may well be little more than a wind shear line or shear zone.

Area G in the northern Gulf indicates the modification of colder air as it streams over warmer Gulf waters. Here, low level moisture is abundant, so that cumulus forms as the lower layers of the troposphere become unstable. The size of the white cloud elements involved seem to be at or near the resolution threshold of the DMSP high resolution sensor, suggesting that the cloud formation process has just begun. The general grayishness of the image in the northern Gulf may also represent low level dust and sand being advected by the shamal winds out over the region from the lower Tigris-Euphrates valley. Reduced visibilities near the surface in this region are implied.